BIOPHYSICS: NEW EVIDENCE FOR THE PLAUSIBILITY OF ELECTROMAGNETIC RADIATION (EMR) BEING THE PHYSICAL BASIS FOR NON-PRECOGNITIVE EXTRA-SENSORY PERCEPTION (ESP)

FRED BLAU

The issue is not whether the phenomena of extra-sensory perception exists, but rather, if electromagnetic or other physical theories adequately describes any or all of the phenomena.

Electromagnetic theories for the phenomena actually predate their opposition by more than three centuries. Apart from Cartesian arguments leading to dualism and materialism, the "mental radio" models have traditionally and even recently been opposed upon at least the four following grounds.

First, that although the high correlation between the electrical activity of the brain and body with many psi phenomena is well established, the brain does not emit coherent energy or radiation detectable more than a few centimeters from the skull. Second, what energies are emmitted loss their power very rapidly, according to the optical, or inverse to the square of the distance rule, and such cannot account for telepathic phenomena which occur over distances of thousands of kilometers. Third, Em theories cannot explain the "down thru" card deck clairvoyance phenomena. Fourth, any explaination of precognition cannot possibly be electromagnetic.

Let it be conceded that the third and fourth objections are valid and well taken. However, as will be shown, there is new evidence that supercedes the first two objections. Although some researchers in this field adhere to an only-one psi phenomena model, we do not. Apparently to some, since Em theories did not account for all the phenomena, it apparently did not account for any of it.

Although it was our original intent to present new evidence for the plausibility of electromagnetic radiation being the physical basis for non-precognitive extra-sensory perception, sometime between the beginning of our research, about a year ago, and the present, it became apparent to this researcher that there is little that is paraphysical about some esp phenomena.

Because we find that parapsychology may be reconciled with psychology, the two synthesized upon classical physics and neurophysiology, this monograph has been altered only in style, but not in content with respect to its stated purpose.

Upon the following quotation rests the foundation of this thesis.

"Finally, extra-sensory perception and sensory perception appear to be much alike except in the relation of the subject to the stimulus. When sensory perception is tested at a low level of stimulus intensity which makes the proccess more comparable to ESP, there is indication that it is subject to some of the influences now known to effect ESP performance." J.B. Rhine (November, 1940)

2. BRIEF HISTORY OF THE ISSUE

Even before the seventeenth century, the topics of consciousness and communication were of central issue to natural philosophy and theology. The phenomena called extra-sensory perception by some, and bio-information by others has a long history of being known by many different names in many cultures and every historical time. It had, by this time, been well demonstrated that man's consciousness was interdependent as well upon his biology and physiology, and that these in turn were influenced by the physical environments.

Although in retrospect the issue concerns itself with the data derived from physics, physiology and psychology, the brief survey presented here shows quite clearly that the investigations undertaken were done so under the notion that the phenomena observed in one specialty was not related to phenomena observed in other specialties. This becomes very apparent when later on, radio phenomena, as practiced by electronic engineers and radio phenomena with respect to esp, bear little relation to each other, in the minds of the principal parapsychological investigators of the mid-twentieth century.

It would be difficult to say when the very first electromagnetic theories of psi first occurred, because the phenomena is described in words that predate modern scientific terminologies. Appropos of the specific issue at hand, the first mention of any phenomena relevant to the perception and/or emission of electrical or magnetic energy by the human organism occurs with Paracelsus (1493-1541). He was a physician and reputedly a psychic healer as well, and he believed that magnetism was a mysterious but natural force, that like the stars influenced the human body, even at a distance, by a subtle emanation that pervaded space. (Boring,1929)

Francis Bacon (1561-1626) in Sylva Sylvarum, or a Natural History provides several accounts of precognition and telepathy, noting that they were natural phenomena, and that it belonged to a class of operations --"emmissions," "transmissions," and influences, which "work at a distance, but not at touch." At about the same time, Van Helmont (1577-1644) originated the doctrine of animal magnetism, by teaching that magnetic fluids radiated from all men, and may be guided by the will to influence the minds and bodies of others. (Gudas

A contemporary of the above was Gilbert, who in 1600 published de Magnete, principally a treatise on the lodestone, Gilbert concluded that the sun and earth were both magnets, the diurnal rotation of the earth dependent upon that magnetism. He also studied the phenomena of "electrica", but did not conclude that there was any relationship between magnetism and electricity.

Again, we find another attempt at a physical or mechanical explanation of the phenomena with Glanvill (1636-1680) who couples a world-soul hypothesis with the observation that "... the agitated parts of the Brain (beget) a motion in the proxime Aether; it is propagated through the liquid medium, as we see the motion which is caus'd by a stone thrown into the water." (Gudas,1961)

It should be understood that at this time philosophers, who were the true forerunners of the psychologists, were debating the issue of whether a materialist or spitualist model most accurately accounted for man's behavior and consciousness. The question which was rekindled by Cartesian dualism is still relevant, and is

still being debated today. It is obvious, even to this author, that materialistic (matter-energy) models are necessarily incomplete with respect to our behaviors and our identities. Accordingly, the validity of the mind-body question is acknowledged, the work of the many philosophers of the post-Renaissance is still relevant today, but we must pass over the history of philosophy and concentrate on the history of the physicalist models.

Anton Mesmer (1734-1818) was a Vienese physician who was able to effect cures both upon psychoneurotic disturbances and physiological ones by the use of hypnotism, which Mesmer claimed was dependent upon a phenomena of animal magnetism. His work is very important to the question of consciousness and control because it stimulated not only parapsychological inquiry, but stimulated the work of Freud and Jung into the unconsciousness as well. The issue, then as now, was whether the cures that Mesmer successfully completed were due to some outside psychokinetic-like force, that is electromagnetism, or whether they were due to subliminal suggestions. Obviously the psychosomatic controversies are raised. Mesmer himself at first used metal bar magnets to produced his effects, but later recanted from their use and came to depend solely on his own "animal magnetism." Because of Mesmer's notoreity a scientific commission was set up in 1784 to investigate the matter. The commission concluded that Mesmer's animal magnetism and naturally occuring magnetism (of the lodestone variety) were not similar phenomena and Mesmer fell into disrepute.

It is about this same time that "animal electricity" is first observed by Galvani in 1780. He discovered that frog's legs, when connected to two dissimilar metals, twitched as tho still alive. Later he created the first "wet battery" by connecting in series a large number of frog's legs. This was in 1794. It is only later that Volta creates electricity from an inorganic battery. It is an oft heard observation that many of man's technological inventions are but projections of his own biology.

By 1827 Ohm had successfully formulated the laws of simple electrical circuits, these laws are still in use today. The major breakthrough in physics of the nineteenth century was the discovery by Faraday in 1831 that an electrical current could be originated by moving a wire through a magnetic field. It was the first realization of the unity of electricity and magnetism. It was only in the next year that the technology had advanced sufficiently for Morse to demonstrate telegraphy, whereby coded signals were carried over long distances by use of cables (transmission line) acting like low frequency lumped parameter systems.

Of great importance to the present issue is the results of an experiment carried out by the psychophysicist Helmholtz in 1850. Before this date the mind -body complex was thought to act together, simultaneously and instantaneously, at or near the speed of light, which was then known to be about 300,000 km/sec. The functions of the nerves were reasonably understood at this time, both anatomically and psychologically, but it was almost universally assumed that the nerves, like Morse's cables, transmitted their data at the speed of light. To his surprise, and many others as well, Helmholtz found that the speed of nervous propagation was 50 m/sec, not only many magnitudes slower than light, but even slower than the speed of sound in air. Now here was a new issue, for man was not only mind and body, he was also not instantaneous in either his perceptions or his

reactions, that is, his control. Darwin's evolutionary theory of 1859 precipitated additional controversy concerning the rise of mechanistic (materialistic) philosophies of physics, biology and history. The schism between science and theology is in part responsible for the founding of the parapsychological and psychical research societies late nineteenth century.

Bernstein in 1866 described the nerve impulse as a wave of negative electricity passing along the fiber. By 1871, he showed that the impulse spread from the negative inside of the fiber to positive outside. In addition it was understood at this time that nerves required a refractory period before being able to fire again. Neurophysiology by this time had identified specific sensory and motor neural locations in the brain and central nervous system.

Maxwell's equations appeared in 1864 leading to the creation of radio wave frequency electromagnetic radiation in 1888. By 1895 Marconi was able to broadcast and receive over a distance of several kilometers, and succeeded in transmitting across the Atlantic Ocean in 1905. Of importance to the biophysical theory of esp is the appearance in 1900 of Planck's law, which accurately describes the energy spectra of electromagnetic energies emitted from an object of a given temperature. For man that temperature is 310°K.

Sir William Crookes (Rhine, 1934) attempts to explain the paranormal phenomena as "high frequency vibrations of the ether generated by the molecular action of the brain." (1897) At about this same time, experimentation based upon Weber's (1834) and Fechner's (1851) laws of stimulus intensity and the threshold of sensitivity ($S = k \log R$) confirm the existence of subliminal (below-threshold) sensitivity. Myer's, who coined the word 'telepathy', in part because he had an interest in 'wireless - telegraphy' also postulated the "subliminal consciousness." Freud (1899) was interested in how the 'unconsciousness functioned in relation to dreams. Although he never acknowledged the phenomena of precognition, in 1925 Freud accepted the existence of the "so-called occult sciences." The additional dream work studies of Jung (1916) and others at this time indicate that the dream is the most frequent state of consciousness in which psychical phenomena occur, accounting for two thirds of all spontaneous psi.

Interestingly enough, that although interest in the psychical, phenomena, in all its various forms, precedes that historically of the interest in analytic psychologies by centuries, the 1914-1918 war apparently stimulated, for a brief time, more interest in the latter than the former.

Between 1911 and 1926 various radio engineers had found that the propagation of radio waves was dependent upon many variables, such as sunspot cycles, the time of the day, the season of the year, etc. Two of the most important variables in broadcasting are the frequency of the signal and the condition of the ionosphere at a given time with respect to that frequency. Theoretical models and empirical data both confirmed that electromagnetic radiation intensity at a given distance (length) is a function of the wavelength, and does not necessarily diminish inversely proportional to the square of the distance, the optical law for visible light wavelengths. The numerical measures of attenuation obtained from the formulas available in 1911 and 1926 do not vary appreciably from the accepted numerical values used today (1975)

Perhaps the first true measurement of the electromagnetic energy emmitted by man was made by Cazzamari, who starting in 1927 and continuing to 1941 measured the phenomena. By using a broadband generator of 60 - 400 Mhz (5.0 - 0.75 meters), he succeeded in resonating with frequencies in the 3 - 400 Mhz (100 - 0.75 meters) range. (These wavelengths include lengths equivlent to average human height. F.B.)

That electromagnetic energy was possibly the agent of telepathy was made popular by many writers, including Upton Sinclair who used the title Mental Radio in his 1929 book recounting his very extensive telepathic experiments. The same year saw the announcement by Berger, that beginning five years before, he had succeded in measuring the electrical activity of the brain, and had found that frequenci of 4 - 20 Hz characteristic normal behavior, and that certain of the frequencies corresponded to certain mental states. In 1941, Dr. Berger announced his approval that brain waves were telepathy after remaining hesitant for some years.

Electromagnetic energy was also being studied with respect to nerves and neurons at this time. Beginning with Phillipson in 1920 and continuing till 1938, various neurophysiologists had measured the capacitance, resistance (impedance) and other current parameters and found that the capacitance and resistance were essentially constant in their values, and only the voltage varied in the neurons. Each neuron was considered to behave as a resistance (and later on impedance) in parallel with a capacitance.

Beginning in the early thirties Vasileyev began to perform many short and long distance telepathy and suggestion experiments. Most noticeable are the results of an extremely long distance test, 1700 kilometers, in which a subject was lowered into a lead bottle, yet the percipient was capable of discerning the state of the subject, who was unconscious. Vasileyev at the time, 1937, was of the opinion that electromagnetic radiation was a highly improbable source of esp phenomena. He did however note that the metal bottle was not capable of shielding Em frequences of the cosmic ray range, or of shielding the frequencies below 10^5 hz, because of their very long wavelengths (greater than one kilometer).

Also very active in this period was Dr. Rhine and his associates. Rhine coined the phrase extra-sensory perception with a tentative meaning of 'perception without the function of recognized senses.' He continues, "esp is apparently independent of recognized energy forms, non-radiative but projectory. .- all quite non-sensory characteristics." (Rhine, J.B., 1964, 1934) Rhine also voiced three objections to the electromagnetic models. First, that electromagnetic radiation loses its power, inversely proportional to the square of the distance. (ibid. pp 158 - 175). Second, he mentions the problems of selectivity imposed by the problem of everybody transmitting continuously or simultaneously. Third, the objection is taken, and well made, that electromagnetism cannot explain the phenomena of clairvoyance, where obviously their is neither an image to send, or even an agent to send it. However, Rhine concludes, (pp 216-222) that esp is a biological phenomena, may be inherited, and 'involves the nervous system quite as much as does any other cognitive process,.." In passing, Rhine lumps telepathy, clairvoyance, and precognition into one category, but telekinesis and psychic healing into separate classes.

Turylgin, in 1937 had found that human subjects felt drowsy when exposed to low intensity em waves. Later, in 1942, he experimented upon the effect of screens and reflectors upon a subject exposed to hypnotic suggestions concerning sweating. Turlygin found the the agent was emitting electromagnetic energies of 1.8 - 2.1 mm (1.67 - 1.43 x 10^{11} Hz).

An Em theory of psi was proposed by Bibbero, in 1951, hypothesizing that x-ray, cosmic rays and gamma rays (10^{19}-10^{29} Hz) were responsible for some of the phenomena. Ruderfer, a year later, suggested gravity fields and neutrinos were responsible.

Lissman, in 1951, had detected extremely low frequency (3 - 3kHz) electrical fields emanating from what were considered to be normal, that is, atypical 'electric fish.'

Neurophysiologist W. Grey Walter commented upon the subject of Em and esp in 1953. He discounted the em models and provided four specific objections. First, "we can calculate that they would fall below noise level within a few millimetres from the surface of the head His second thru fourth objections occur in one paragraph:

> "The size of the electrical disturbances which the brain creates are extremely small. In fact, they are about the size, within the brain itself, of a received signal which is just intelligible on an average radio set. More crucial even that this, their dominant frequencies are far below the range of radio channels, below even the scale scale of audible frequencies. At ten cycles per second, the average frequency of alpha rhythms, any electromagnetic signal transmitted thru space would have a wavelength of thirty million metres."
>
> Walter, W.G., The Living Brain, 1953, pp 252-3.

It should also be mentioned that Grey noted the lack of the phenomena to be significantly attenuated either with respect to space distance and time distance, so he apparently at the time adhered to the one-psi phenomena model.

Following his earlier work, Lissman, in 1958 had succeeded in conditioning fish with currents as low as microvolt per meter(V m-1) By 1960, based upon the work of Bullock and Hagiwara, a new sense organ, the electroreceptor, was identified and found to be phylogencally a member of the acoustico-lateralis system. The basic electroreceptor was similar to the cilia-in-jolly secondary neurons of the auditory system, which were then thought only for mechanocal and temperature sensitivity.

Rashevsky (1955) does not state himself directly on the subject, noting also the obviously non-physical esp phenomena. However, he completely maps out the necessary physical conditions necessary for the operation, observation and testing of em psi models. He says, "Experiments by Edmund Jacobson (1930) indicate that thinking results in measurable action currents in the external muscles of the body. Such action currents, small as they are, of necessity create electromagnetic fields. Unlikely as it is, it is not impossible that some highly sensitive nerves may respond to these fields."

In 1962 just such an electrosensitive response was observed by Frey. Using frequencies of $4 \cdot 10^{8}$ - $3 \cdot 10^{9}$ Hz (1.0m-0.1m) human subjects reported a buzzing or clicking sensation, only if the temporal lobes of the brain were included in the illuminated area.

Frey hypothesized that the cochlea was involved in the phenomena but he adds that there is probably more than one electrosensitive site.

Puharich, in Beyond Telepathy, 1962 correlates psi receptive phenomena with cholinergia and other physiological processes. He hypothesized that gravity and "psi plasma" were partly responsible for some of the telepathic phenomena. Because of the Faraday cage experiments he performed he states, "While the experiments are highly suggestive that electromagnetic radiation is not the means of transmission in telepathy, they are not means conclusive." He notes that while in the cage, one subject showed a pronounced gasping effect when 640 Hz ac was applied to the cage. With respect to the nerve plasma membrane, he calculates that the neuron could be considered a circuit of megaohm resistance, micro-farad capacitance and 0.2 henry inductance, the latter fact first reported in 1941 by Cole and Baker.

The next year, 1963, micro-oersted, 1.0 Hz magnetic fields were detected emanating from the human heart by Baule and McPhee.

Wooldridge (1963) commented upon the telepathy--emr issue noting the the difficulty involved was in deciphering brain waves since they represented the average electrical strength of billions of neurons, there was no possibility of unraveling the specific thought processes.

It is in 1964 that Mancharski states that telepathic communication occurred at frequencies from infra-low to super-high (10^{-3} to 10^{12} Hz. Although I have not seen his thesis, the hypothesis put forward in this monograph perhaps best corresponds to Mancharski's hypothesis.

I. M. Kogan, in 1966, hypothesized that long wave electromagnetic radiation of 26 km to 960 km wavelength (11,000 to 310 Hz) could account for the phenomena because at this wavelength the field strength does not obey the "optical" rule. Based upon calculations, which regrettably I have not seen, Kogan indicates that the human organism generates four to five times the necessary signal strength to accomplish very long distance telepathy.

Two prominent parapsychologists, Burt and Dobbs commented on emr and physical theories of psi in 1967. Burt announced his opposition to the emr theories based upon the objections that 1) the inverse square law diminished the signal strength rapidly, and besides the wav lengths associated with the brain waves (3-30 Hz) were very (too) long In addition, 2) he calculates that because the observed change in the evoked potentials was 5-50 microvolts, the corresponding power was 10^{-20} watts. To broadcast the observed distances, Burt indicated that a minimum power of 10 watts would be necessary. Finally he noted that some modulation or coding of the signal was also a necessary prerequisite. Dobbs however rejects the validity of the inverse square (optic rule, based upon the ionospheric effects at ELF frequencies long observ by radiomen. However, Dobbs questions the emr theories because the ca culated field signal strength at the human scalp was on the order of 10^{-18} watts. Kamiya (1968) rejects the emr theories of telepathy of essentially the same arguments as Burt.

In his Electromagnetic Fields and Life (1968), Presman reviews the complete history of the studies of sensitivity and emissivity of electromagnetic radiation by living organisms. He acknowledges bio-information transfer by emr fields, but is care not to deny the phenomena while criticizing " the parapsychologists and their methods.

It is in 1968 that the electromagnetic fields generated by ELF brain waves are first observed by Cohen. Using a cryomagnetometer 5 cm from the skull coupled with contact EEG electrodes, Cohen found that the brain emitted Elf dc fields of $2.5 \cdot 10^{-8}$ gauss, and later work showed that the skeletal muscles emitted 1 - 100 Hz dc fields of 10^{-7} gauss.

Early in 1975 Persinger hypothesized that the 7.8 Hz frequency associated with the first earth-ionosphere waveguide resonance is the primary carrier of telepathy. In addition he hypothesizes that magnetic fields should inhibit the phenomena, as well as noting some slight west-east propagation differences. In addition, Persinger has done some of the most comprehensive experimentation and research with respect to the biophysical effects of ELF and VLF electromagnetic radiation. He reports the ELF brain wave field at 1 - 10 $mV \cdot m^{-1}$.

In mid 1975, Blau calculated the emitted brain wave frequency field strength as exceeding the microvolt per meter level.

Puthoff and Targ, in work completed in November 1975 and publishe in March 1976 discuss the ELF-telepathy hypotheses and reject them under the considerations then that while the attenuation of the field strengths over very long distances were very low, ELF could not account for the precognition experiences recorded in their remote viewin experiments. Their second objection to ELF/VLF concerned the (reporte channel capacity of the band as 0.1 bits $\cdot$ sec^{-1} at meter range distances and 0.001 bit $\cdot$ sec^{-1} at 4,000 km range. The above authors apparentl adhere to an only-one-psi phenomena model.

. . . .

This very brief history of the issue concerning the hypotheses and counter hypotheses regarding non-precognitive 'psychic' phenomena is presented an introduction to the question which is discussed in more detail in this monograph. Some historical priorities may have been missed in this introduction but have been corrected in the text. Our monograph is the collection of the work of many researchers over many years, the author has merely synthesized it and therefore defers to all those mentioned herein any claim to originality or priority.

A technical abstract of the hypotheses appears on the next two pages.

3. SENSITIVITY AND RESPONSE TO STIMULI

The various phenomena such as telepathy, clairvoyance and precognition are called extra-sensory perceptions by psychic researchers primarily in Western Europe and North America, whereas the same phenomena is called bio-information primarily in East Europe and the Soviet Union. In part, the study of the phenomena has been influenced by what it has been called.

Although Burton in 1870 uses the terminology "extra-sensuous perception", its present meaning, as popularly understood, is coined by J?Rhine to describe psychic phenomena as non-sensory and aphysical. At the time, Rhine included the possibility of the phenomena being sensed by an as yet unknown sensory perception; upon other considerations he rejects any "sixth sense" hypotheses.

Clearly however, before any phenomena may be characterized as non-sensory or extra-sensory, an examination of sensory perception per se must show that sensory perception is inaedquate. This is very important since the quotation at the introduction of this monograph suggests that sensory as well as extra-sensory perceptions appear to behave alike in the region of marginal sensitivity. It shall be shown in this chapter that not only are there several receptors capable of response to electromagnetic energies, the applications of classical psychophysics reveal several normal modes of sensory perception which facilitate the electromagnetic responses.

The relationship between the intensity of a stimulus and the subjective intensity of response was initially investigated by Weber and Fechner in the nineteenth century. In general, as expected, the sensation increased as the intensity of the stimulus increased. The corallary of this law states that the just-noticeable-difference in stimuli was a constant numerical value for a given input intensity.

(3.1) $$\frac{dR}{R} = k_{*} \text{ (jnd)}$$ (Weber's Law)

(3.2) $$S = k \log \frac{R}{r} \quad a$$ (Fechner's Law)

where
k, a = constants
R = stimulus (Reiz)
r = liminal value of stimulus
S = sensation

Careful consideration of the logarithmic relationship between stimulus and response indicates that 1) there is no such phenomena as a zero-intensity stimulus, and 2) sensation below the limen (threshold) is theoretically possible. Such sub-conscious as subliminal conditioning, as well as memory of events consciously unattended to is cassical psychological fact.

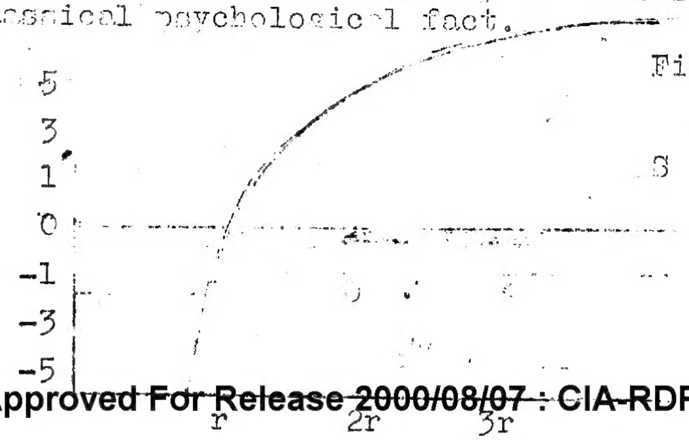


Fig 2.1 Fechner's Law

$$S = k \log \frac{R}{r} \quad a$$

By definition, the relative threshold is that stimulus intensity which evokes response 50% or more of the time. Similarly, the absolute threshold is that stimulus intensity which fails to evoke response in 99% of the test trials. However, the absoluteness of these threholds can be called into question due to a Gaussian distribution of individual's sensitivities. Various studies show that in individuals the thresholds may vary from as much a 5 to 15 db from the collective threshold standards. In passing we note that the possessor's of some psychic abilities are sometimes referred to as "sensitives."

In addition to the intensity of a stimulus, the threshold of sensation is also a function of the duration or novelty of the stimulus. In general, increasing the duration of the stimulus lowers the threshold for sensation; however, there is a point, called the rheobase, beyond which increasing the duration lowers the threshold no further. The combined effects of differential sensitivity and the duration threshold phenomena rarely contribute however to make more than 5-15 db gain in sensitivity of any given individual. Tho it should be added that that amount of gain is sufficient to make the difference meaningful.

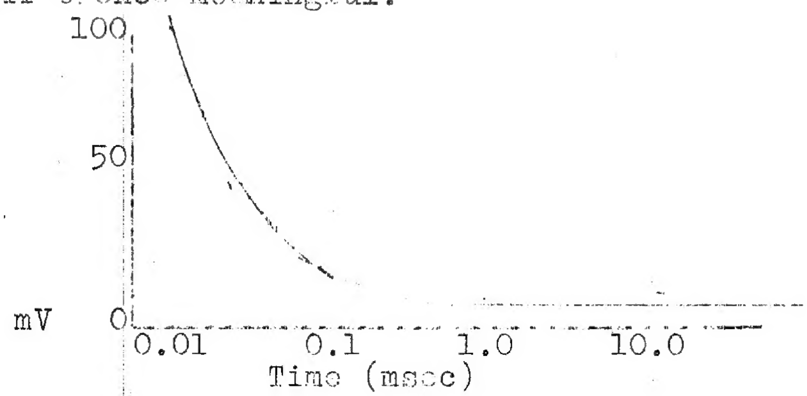


Fig 2.2 Typical strength-duration curve.

Relative also to the question of sensitivity is the observation that the ability to perceive a given signal which is immersed in noise increases as the square root of the number of observations of that signal. Altho this does not increase the threshold of sensitivity beyond its relative or absolute value, spatial summation, as the phenomena is called, indicates that provided a stimulus is suprathreshold, the more frequently a phenomena has been observed before, the easier it is to detect when imbedded in noise or distortion.

(3.3) $$G_{ss} = 10 \log_{10} n^{\frac{1}{2}}$$

where G_{ss} = Gain in decibels (db) spatial summation
n = Total number of observations

For example, consider that there are 31 million seconds per year. What is the theoretical gain for spatial summation for a twenty year old adult for a 10 Hz signal.

(D 3.1) $$n = \frac{3.1 \cdot 10^7 \text{ sec}}{\text{year}} \times 20 \text{ years} = 6.2 \cdot 10^8 \frac{\text{sec}}{20 \text{ years}}$$

$$= \frac{10 \text{ waveforms}}{\text{sec}} \times \frac{6.2 \cdot 10^8 \text{ secs}}{20 \text{ years}} = 6.2 \cdot 10^9 \frac{\text{waveforms}}{20 \text{ years}}$$

$$n^{\frac{1}{2}} = 7.9 \cdot 10^4$$

$$G_{ss} = 49 \text{ db}$$

Similarly, what is the spatial summation gain for the same adult for a 10^8 Hz signal?

(D 3.2)

$$n = 6.2\cdot 10^8 \text{ sec} \times 10^8 \text{ waveforms/sec} = 6.2\cdot 10^{16} \text{ waveforms}$$

$$n^{\frac{1}{2}} = 2.5\cdot 10^8$$

$$G_{ss} = 84 \text{ db}$$

Eq. 3.3 therefore, is one of the equations which relates perception to learning. Relevant to telepathy, spatial gain allows the perception of signals when imbedded in noise due to crowds or noise created by natural or artifical signal generators having field strengths substantially greater than that upon the same carrier frequency. Spatial summation then acts like memory, and in fact is one of the sub-phenomena which makes up the general phenomena of memory.

Therefore, the threshold of sensation cannot be said be be a cut-and-dried matter of a specific numerical value of stimulus. For it is not only true that the value of the threshold may change dependent upon the length of presentation, it will vary as well dependent upon the familiarity gained by previous presentation. In addition, there are some phenomena which are perceived solely because they represent a single discrete event. Presentation of the same stimuli in a series sometimes does not evoke any response.

Before we leave this introduction to perception per se, it bears repeated emphasis that the whole nature of thresholds and perceptions includes the phenomena of subliminal conditioning. For it is of great importance that subconscious response occurs to subliminal stimuli. If we remember that the nature of thresholds is often determined by the verbal response of a subject, the nature of the threshodd is determined not by whether or not the subject is effected by the stimulus, but rather, if he is conscious of it. It is now widely accepted that much of man's behavior is subconscious, he is not aware generally of how he does what he does. Consciousness represents only the tip of the iceberg. The problems causes Sorokin to note that there are two schools of thought, one that sees consciousness as the master of being, the other to see consciousness as the servant of being.

Lastly, as far as this general introduction to sensation and perception is concerned, it must be noted that altho a given stimulus may be objectively classified as to some intensity or quality, the nature of perception is subjective and associative. For example, in one recent telepathy experiment, an image of a farmer with a pitchfork resembled to the agent who drew it, the mythical figure of "the devil," however, the percipient whose culture differed from the agent's had not in his vocabulary the notion or symbol for "devil,", but instead received the emotional association of something religous, and so drew instead a figure of opposite meaning, ie, the tablets of Moses, still however correctly "religous." (Targ and Puthoff)

Similarly, in a study replicative of Penfield, Sem-Jacobsen et al had placed 2652 electrodes in 82 surgical patients over a period of ten years. Altho no response was elicited from 1065 electrodes, about half of the remaining electrodes (805/1587) produced singular and discrete responses. Of interest to us is that of the other half of those electrodes eliciting responses, multiple associations were produced. For

example, 104 electrodes elicited visual responses, of which only 42 were uniquelt vi ual, the remaining 62 responses were visual, with the following multiple associations in order of prevalence; sensory, mood, motor, vegatative, cardiovascular and consciousness. Considering the oft mentioned importance of imagery in psi phenomena, the oppurtunity for confusion and ambiguity is readily observed. (Sem-Jacobsen and Styri, 1971)

Let us also mention, in passim, the phenomena of paradoxical hot and paradoxical cold, of which more later.

Therefore, there are four levels of differentiation concerning this process: first there is sensation, by which we shall mean the objectifiable properties of intensity and quality; second there is sensation, which may be unconscious or conscious; third, there is perception, by which we mean here, the conscious awareness of sensation; and fourth, there is interpretation and decoding.of the phenomena.

3.2 SENSORY CODING

Our human bodies are an ensemble of masses and energies, and our environment is also an ensemble of masses of various qualities and energies of various frequencies and intensities. Thus we and the universe are subject to the interactions of masses and energies, according to the laws of physics. When we are acted upon by the universe we are imbedded in we say that in the environment is an stimulus, which may produce in us, a sensation, which is not necessarily an awareness. Through the biological evolution directly dependent upon physical environment, generalized and specialized 'receptors' have been created in organisms, which thru selection allow an organism to appropriately respond to that environment and survive.

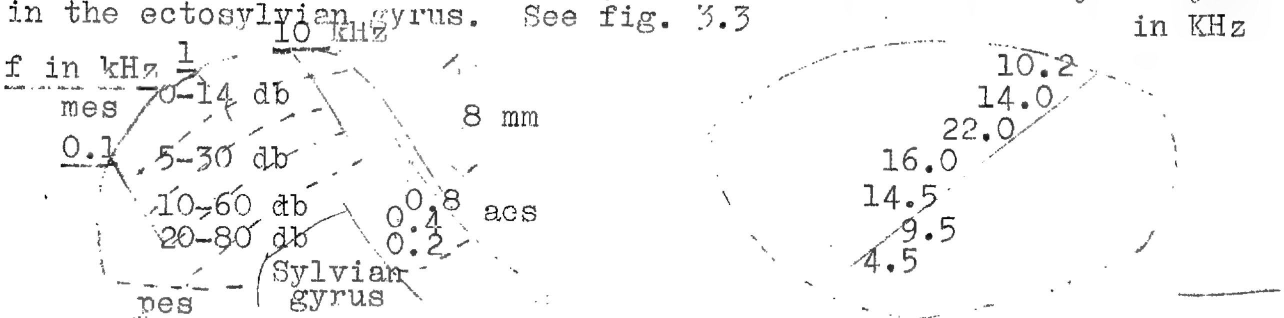
Altho we shall soon discuss the various receptor physiologies and mechanisms, of supreme importance is that when all the various mechanisms have done their intermediary functions, what is produced by the sense receptors is an information or code which is a map of the stimulus that produced it. What is coded in sensory process is information about what kind of stimulus is there and how much.

The variable involved in taste and smell is the concentration of a given ion or molecule, which on the quantum biochemical level is essentially electronic and therefore a function of some electromagnetic frequency. In hearing and touching, both 'mechanical' senses there are two variables, the intensity of the pressure and the frequency of the change in that pressure. Similarly in electroreception ((ELF, temperature (infra-red and vision)) the stimulus also varies in intensity and frequency.

Now, once a stimulus is superthreshold, a current is generated in that receptor, called the generator potential, which is a graded response to the stimuli. This graded, that is , variable potential is then synapted into the afferent nervous system, whose neurons create an all-or-none potential of constant voltage, (viz Hodgkins-Huxley model) such that what is transmitted by the afferent neurons is a code based upon the frequency of impulses conveyed by the neuron,(and this is supremely important for the reader's understanding,) and not the voltage of that impulse. (We mention this for the variable voltages seen in brainwave potentials is the statistical summation of the constant potential of a varying number of cortical and inter-neurons.)

Of the approximately ten to twenty billion neurons in the human body, only about 0.1 billion are afferent sensory neurons capable of producing graded generator potentials. The two primary sources of human bio-information are vision, which is electromagnetic radiation between the frequencies of $4 - 7 \times 10^{14}$ Hz, and audition, which is mechanical oscillations between 30 Hz and 24,000 Hz. The nature of neuronal response is such that most nerves are tuned, eith widely or narrowly to a specific frequency, such that when a neuron is activated the specificity of the neurons automatically, and usually, uniquely is addressed with a specific band of frequencies, such that the message encoded is the intensity of the stimulus acting upon the already frequency-specific neuron.

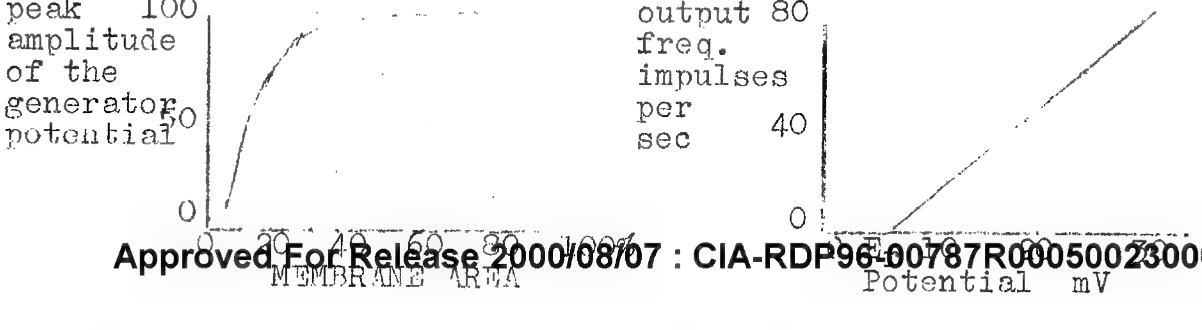
In addition, the brain, where the afferent signals have their destination, is arranged tonotopically; that is, a specific frequency (tono) is located in only certain allowable structures of spaces (topo in the brain. Several such tonotopic mappings hace been observed, as for instance the cochlear nerve, and the central auditory analyzer in the ectosylvian gyrus. See fig. 3.3



Now, altho the frequencies of the auditory and visual stimuli are respecticely in the KHz and 100 THz ranges, the frequencies at which both the generator and action potentials operates are tens to billions of times less frequent than the input stimuli. Thus, the generator potentials, which may be added together, have no refractory period, but a spike duration of 1-2 msec is de facto limited to firing frequencies no greater than 500 to 1000 Hz. Similarly, the constant voltage action potentials have refractory periods of about 1 msec and so are also limited to firing frequencies below 1000 Hz.

Since, as we shall show later (Cf ch 5), that neurons firing below say 500 to 250 Hz do so with inductive reactance, ELF electromagnetic fields are created. Of importance to our study of consciousness and telepathy, practically all sensory information is created into frequencies in the ELF range.

The nature of sensory transduction is this: a stimulus of a given intensity acts upon an afferent nerve, which is a membrance which conducts ions. The larger the intensity of the stimulus, the greater is the membrance area activated, and since this means a larger flow of ions and electrons thru that membrance, this determines the amplitude of the the generator potential. The amplitude of the generator potential, once synapted (either excitory or inhibitory), determines the frequency of the action potentials. See fig 3.4 below



Investigations have been made relating the intensity of the input stimuli to the frequency output for all of the sense modalities. Stevens hypothesizes that the sensory transduction process follows a power law, ie

$$f_o = ax^n \mp b \qquad 3.4$$

where f_o = output frequency
ax^n = dynamic discharge response to stimulus
= static discharge rate.

When 3.4 is rewritten, we see that this is simply a form of

$$\log f_o = (n \log x \pm \log a) \pm b \qquad 3.5$$

the Weber-Fechner laws relating sensation to stimulus, except here the relationship is the frequency of neuronal output to the stimulus intensity. Altho most transduction processes follow the power law over a certain range of input stimuli, it has been hypothesized (Lipetz) that the transduction process is better described by

$$f_o = \tanh x \quad \text{(hyperbolic tangent)} \qquad 3.6$$

Since, as we shall show, the greatest majority of output frequencies are between 0.01 Hz and 500 Hz, some mechanism must provide discrimination for all the messages crowding this given band, which because of the extremely low frequencies, have a limited channel capacity. In part this identification comes from the exponent which is generally unique for a given sense modality. Of importance is that these exponents exhibit values generally indicative of the oft observed property of differences due to organism individuality. A corollary to this would be that there is probably no universally compilable frequency or waveform dictionary.for some phenomena.

Table 3.1 is an arrangement of the various observed power law exponents as compiled by Stevens and by Lipetz from a large number of investigations completed on the average, since 1965.

TABLE 3.1 -- Power Law Exponents

0.10 - 0.18	Vertex potential	1.0	Cold on arm
0.21	light intensity av. cortical potentials	1.0	Visual length
0.33	Brightness 5° target	1.05	Sucrose -av. of 14 subj.
0.52	Av. cort. pot. 200 Hz vibration on finger	1.11 - 1.97	Salt
0.62	Same as above, 50 Hz	1.1	White noise duration
0.67	Loudness 3000 Hz tone	1.1	Vocal effort sound pressure
0.6	Smell - heptane	1.1	Static pressure on skin
0.67	Depolarization current optic nerve at 550 nm	1.20	Depolarizing current for 680 nm
0.7	Projected visual area	1.3	Finger span
0.716	Intensity - light	1.45	Heaviness- lifted weights
0.735	Intensity - 680 nm	1.47	Citric acid-one subject
0.8	Tactual hardness	1.5	Temperature-warmth on arm
0.85	Citric acid one subject	1.5	Tactual roughness
0.89	Illumination	1.7	Force of hand grip
0.975	Light intensity 620 nm	3.5	Electric shock- current through fingers

Although the maximum firing rate of a given sensory afferent or motor efferent neuron is limited to frequencies (usually) below 1000 Hz either because of refractory period or spike duration, it is also understood that stimuli change rapidly, so that the actual signal is usually limited to only a limited number of waveforms in any given time interval. The various coding/transducing processes provide several different modes wherein the frequency of neural discharges provide unique and unambiguous information about the stimulus. For example, in phase coders (T-type) or latency-burst dispersion coders (D type), a given neurons' output frequency is relatively constant over any given long duration, lets say 120 impulses per second. The coding occurs by the mechanism that the discharges vary from their normal interspike interval by only a few tenths of a milli-second, the information thus being a code based upon the phase or earliness-lateness of a given spike with respect the the average interspike duration. Bullock, from who the above coding schema are credited indicates that at least two additional codings occur: one, a probability coder (P-type) which produces spikes in a quasi-chance manner, and two, a burst coder (B-type which produces spikes in clusters of varying number. (Szabo and Fessard

Once a stimulus is superthreshold, a signal proceeds into the brain structures by various multiply-synapted afferent pathways. Once in the appropriate cerebral structure the incoming information is processed in masse, producing the phenomena of averaged cortical responses. It has been shown that these average cortical potentials have almost unique waveforms for the given sensory input. The average potential's voltage amplitudes vary upon the mechanism of whether or not the appropriate neurons fire in phase. When neurons of a given constant voltage and given output frequency discharge, amplitude modulation (ie of voltage) is a function of the phase differences between those neurons.

For example, in a neuron firing at 60 Hz, there is one spike every 1/60 of a sec, or 0.0167 sec. If another neuron, regardless of its output frequency delivers to some cortical structure an impulse that arrives simultaneously with the above 60 Hz frequency, the two waveforms, much like oceanic tides,crest together, ampliflying the voltage of the thus averaged cortical response. However, should the two (or three, or n) signals be out of phase, varying degrees of additive or subtractive construction will occur in voltage amplitude.

Consider then that the message or meaning (not the information as we shall later specify) is function of several factors: the sensory out-put frequency, all usually under 1000 Hz; the power law functions of the modalities, which discriminates but their rate of change, (that is growth) the modality; and the amplitude of the averaged cortical responses, a function of the phase of the incoming frequencies.

The following is then very illuminating. Amplitude modulation (AM is a function of phase. However, the time rate of change of phase, that is its first derivatioe, is degrees per second, that is frequency. Now, in addition, the waveforms are transient, growing and diminishing rapidly, and the frequency also changes with respect to time and the first derivative of frequency is change of frouency per time, or as we know it, frequency modulation (FM). Therefore, the 'message' is a function of phase, the first derivative of phase, which is frequency and the second derivative of phase, which is frequency modulation.

$$\text{Message} = \underset{(AM)}{\phi} \pm \underset{(FREQ.)}{\frac{\Delta\phi}{\Delta\tau}} \pm \underset{(FM)}{\frac{\Delta\phi^2}{\Delta\tau^2}}$$

For the sake of simplicity, the coefficients have been eliminated from Eq. 3.7 , but it should be understood that in any given 'message' the coefficient of any term may be zero, limiting that message' to only one or two of the possible three components.

All of the sensory codings we have seen, or shall see, are some variatiation upon frequency coding, yet there is another aspect to those codings which illuminate the nature of perception most poignantly. Most of the codings we shall examine are continuous, that is they may have any value from the minimum to the maximum for that given sensory modality, except those of olfaction, and perhaps some others that have not yet been investigated.

Hughes et al implanted electrodes into 23 patients during ortho neurosurgery. Standardized atmospheric solutions of various odorants were administered to the patients and responses were recorded from the olfactory bulb, and amygdala of the conscious subjects. The results can only be described as revolutionary, for what Hughes and his co-workers had found was that odor qualities were recorded into specific, that is discrete frequencies, rather than a wide band of frequencies. Altho some of the lines responded to more than one stimulant, it could be said in general that only very specific frequencies were allocated for very specific odorant qualities, the result being that some sensory coding was as accurate and as specific as emission or absorption lines from stellar spectra. Here it can be said is specific evidence for a dictionary-like frequency code of sensation. Table 3.2 lists the major frequency components in cycles per second, in a human olfactory bulb. (J.R. Hughes, et al)

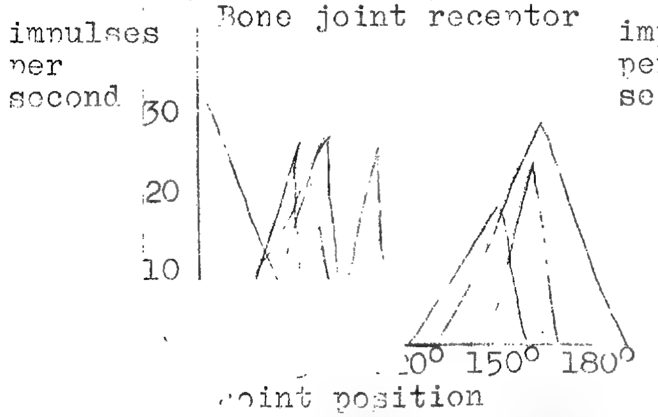
Table 3.2
Olfactory spectral Lines

Odorant										
Menthone			30.3	46.0		51.6		57.3		
Peppermint	25.8		30.3			51.6	53.3		65.9	68.5
Eugenol		26.4	30.3		50.6	51.6				

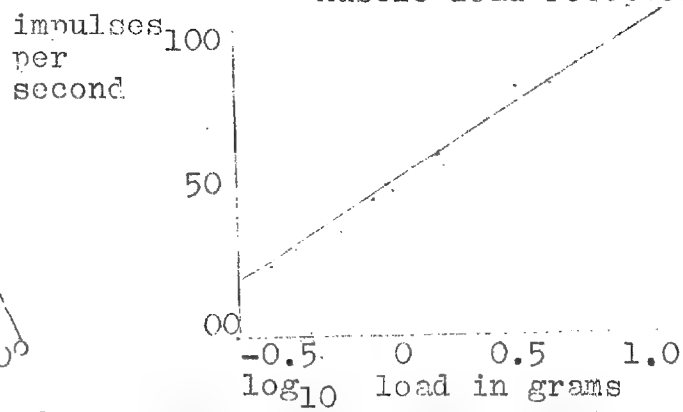
additional common lines occur at 70.8, 72.9, 73.9, 75.8 and 79.9, with components higher than 140 Hz being very rare.

Let us conclude this section on sensory coding by showing two diagrams. The first, figure #3.5 shows the output frequency of bone joint position receptors, and the second, shows the output frequency of a muscle stretch receptor. Although the reader is asked to verify, as we shall later show, that audition and vision output frequencies do not exceed 500 Hz, the following diagrams are added evidence that no sensory output frequency exceeds 500 Hz.

Bone joint receptor



Muscle load receptor



3.3 Electroreceptors and the Acoustico-lateralis System.

Although it is popularly accepted that there are five senses, ie. smell, taste, touch, audition and vision, recent physiological work has identified many additional sense modalities, including pain, carbon-dioxide and specialized electroreceptors. Of interest to the topic of sensation and perception is the fact that a given physiologic identified sense organ may respond to more than one input sense modality. For instance, pressing the eye lightly creates visual 'phosphene images, whereas certain pain and thermal receptors in the skin respond as well to pressure. Additionally, pain may be perceived by injury in areas in the skin which are not innervated by either touch, pain or thermal receptors.

In this section we shall demonstrate the existence of specialized electroreceptors, but it is our additional thesis that all neurons and some synapses are electrosensitive. Consider, for instance that that which we call taste and smell is really a function of given concentrations of ions, which themselves are electrical charges of specific polarity (valence) and frequency. Similarly, that which we call hearing occurs when a mechanical vibration acts upon the cilia in the organ of Corti, it is the stress-strain mechanical energies of the cilia which create heat (infra-red) which stimulates the auditory neurons; the specific mechanism is called piezoelectric. Thermal receptors respond to "heat", but that which we call "heat" is specifically infra-red electromagnetic radiation. Finally we shall not belabor the point that vision is the response to electromagnetic radiation in the "visible-light" frequencies.

The specific electro-receptor organs as described forewith are all revealed from research in ordinary and electro-sensitive fish. However, since our thesis is specifically electromagnetic reception in the ELF bands and the 25m to m band, the reader shall keep in mind that these electroreceptors are part of the acoustico-lateralis system, of which the cochlea and semi-circular canals in man have evolved, and also closely resembles the "acupuncture point system," both shown to be electrosensitive.

Leydig in 1851 had studied the lateralis system and concluded a sensory function for the organs. Later, Schulze, in 1861, had hypothesized that the cupulae of the system were stimulated by 1) water movements directed against the fish or amphibian, and 2), low frequency vibrations (sound) in the water. Sand, in 1938 demonstrated that the ampullae (of Lorenzini) were infra-red sensitive. In 1955 Hensel confirmed Sand's work and extended it to show the similarity with mammalian thermo-receptors.

Lissmann, in 1951, had discovered a low voltage 0-330 Hz steady discharge from electric organs, and later succeded in conditioning a species of fish to microvolt ELF fields. Bullock et al, in 1961 hypothesized that the specialized electro-receptor organs were derivati of the lateral line sense organs. (FESSARD, 1974, ed.)

The specialized lateral line organs of which we shall soon speak occur in integration with the ordinary lateral line systems, that is, not in substitution. It should be mentioned that species not containing the SLLO responded to electrical fields of mV intensity in the ELF range.

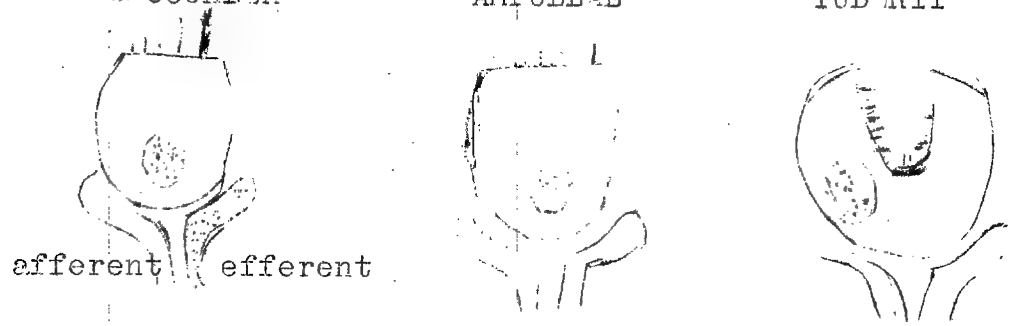
There are three basic types of lateral line organs. The first are the ordinary LLO, second and first order neurons capped with microvilli, in general only mechanically sensitive, however, still piezoelectric.

Ampullae, viz ampullae of lorenzini, are canals, usually 1cm long by 1mm in diameter, filled with an acidic mucopolysaccharide, and are directly connected to the epithelial layers. The wall resistance of the canal is 6M $\Omega\cdot cm^2$, with a capacitance of 0.4 -0.8 $\mu F\cdot cm^{-2}$. The jelley however, has a resistivity of 25-31 $\Omega\cdot cm$, and a composition that varies somewhat spatially, but in general is, in $mM\cdot kg^{-1}$ H_2O, Na(2) 445 Ca(2) and Mg(2) 50, Cl(-1) 580, K(1) 12.5, and urea 75 (MURRAY)

The ampullae occur in many varieites of fish and amphibia. In general the end organ is 10-15 μm in diamter, with groups or clust ers of 10-50 ampullae per organ. The density of the organs range from 12-80$\cdot mm^{-2}$, and may number a total of 40,000 in any given species. Of specific interest to us is that the ampullae respond to field streng of 1-15 $\mu V\cdot m^{-1}$ iff and only iff the input frequencies are low, that is in general, less than 300 Hz, and most often, less than 50 Hz.

The third type of lateral line organ is called tuberous, and is found only in weakly electric fish. The tuberii are located in invaginations below the epithelius and surrounded by supportive cells. The tuberii responded to fields of 4-20 $\mu V\cdot m^{-1}$ of high frequency, usually up to 1000 Hz, specifically synchronous with the electric organ discharge of that fish or of electric fish of the same specie.

Figure 3.6 shows the comparative physiology of the three receptor organs. Ordinary lateral line electro-receptors are innervated by an efferent neuron, the ampuallae and tuberii are not.



Specific electro-sensitivity was demonstrated by Dijkgraaf and Kalmijn (1963, 1966, 1971) in a series of experiments emphasizingboth electrolocation and conditioning stimuli phenomena. At first they noticed that dogfish responded to a 5 Hz 10^{-5} $V\cdot m^{-1}$ field by a twitchin of the eyelids, interestingly enough, when the dogfish were drowsy. (Altered States' researchers, take note!) Later they noticed that when the ECG was monitored, the heart rate slowed from 1 Hz to 0.7 Hz when stimulated by 10^{-6} $V\cdot m^{-1}$ fields. Late in 1966 dogfish were trained to seek food with a 4×10^{-5} $V\cdot m^{-1}$ field. In all cases, the responses to stimulii or conditioning ceased when the ampullary nerves were sectione even when the field strength was raised 30 db (1000 X). In addition it was noticed that the dogfish naturally avoided areas where the field strength was 1- 0.1 $mV\cdot m^{-1}$.

Three types of responses to E fields were noticed. The first reaction was a twitching of the body or appendage, usually in response to 10 - 1 $V\cdot m^{-1}$ fields, but sometimes as low as 10^{-2} $V\cdot m^{-1}$. The second

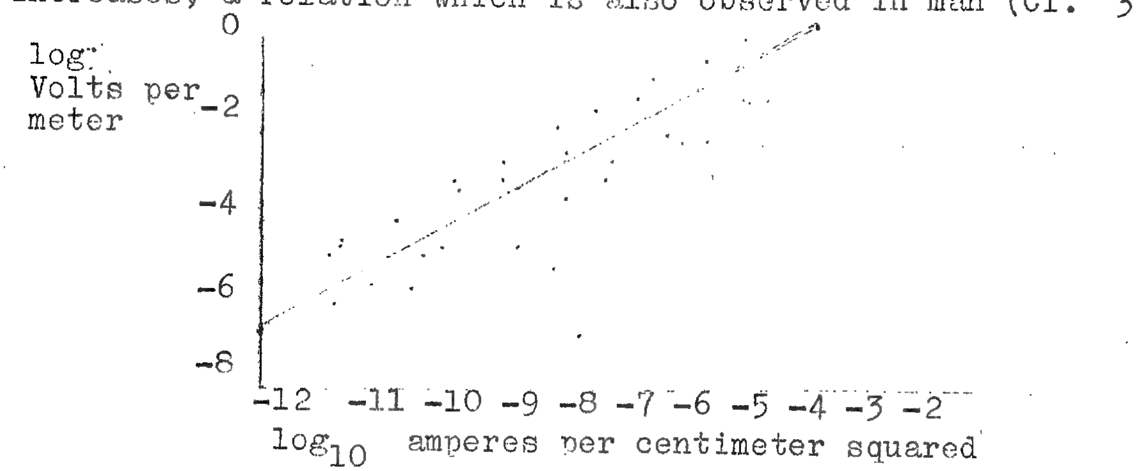
response type is galvanotaxis, a turning into or perpendicular to the field. The third response type is galvano-narcosis, an immobilization of the test subject.

Final proof of specific electrosensitivity was provided by Kalmij who sequestered a flatfish 'prey' in sand, and with other controls excluded visual, mechanical or chemical clues, yet the sharks and rays were able to locate the flatfish. Extra weight is added to the eviden when an artifical current similar to that of the flatfish produced the same location results.

Figure 3.7 below is an adaptation of Table2 (in Kalmijn (1974), which plots the electrosensitivities of the various species tested by numerous authors. Two types of electrical energy parameters were present at the time of testing, one being field strength, in volts per meter ($V \cdot m^{-1}$) and the other being current density in amperes per centimeter squared ($A \cdot cm^{-2}$). Curve fitting reveals that the relation between the two threshold parameter is

(3. 8) $\log V \cdot m^{-1} = \log A \cdot cm^{-2} \quad 5.0$

Figure 3.8 below shows that in sharks and rays, generally consider weakly electro sensitive, the relation between current density and input frequency reveals that the threshold increases as the frequency increases, a relation which is also observed in man (Cf. 3.6 - 3.9).



Although specific electroreception has been demonstrated by Lissmann, Bullock, Kalmijn and others, of specific interest to us is that the ampullae have been demonstrated to be widely receptive to other electrical and para-electrical phenomena. The reader is requested to study the following closely, for what has been demonstrated in the ampullae of fish has also been observed in man, that is both wide and narrow electro-response.

Here the work is primarily due to Murray, specifically on the ampullae of Lorenzini. Our interest in this organ is due to the fact that it is widely distributed in vertabrates, and its response to electrostimuli is a tonic, that is frequency coded message, whereas the tuberii, found only in fish possessing EOD, responded with phasic, burst-dispersive andtonic-phasic codings.

Figures 3.9a to 3.9b below show the following responses of a single unit of ampullae. In 3.9a the input parameter is voltage and polarity. Notice that the organ has a discherge rate of about 30 Hz, and the output frequency therefore codes polarity and intensity. Notic

also the output frequencies in all cases are in the ELF range (3 - 3 kHz). Figure #3.10 shows the response of the same unit to temperatu (infra-red), while figures 3.11 abc record the response to pressure and touch (via the piezoelectric effect), and finally, figure 3. 12 reveals the response of an ampullary organ to the application of a sea water solution of various salinities. (It should be noticed that the average concentration of the neural solutions are two to three tim that of sea water.) Again, what is most important here is the wide range of electro-sensitivities of the ampullary organs.

Fig. 3.9 Response to electrical stimuli

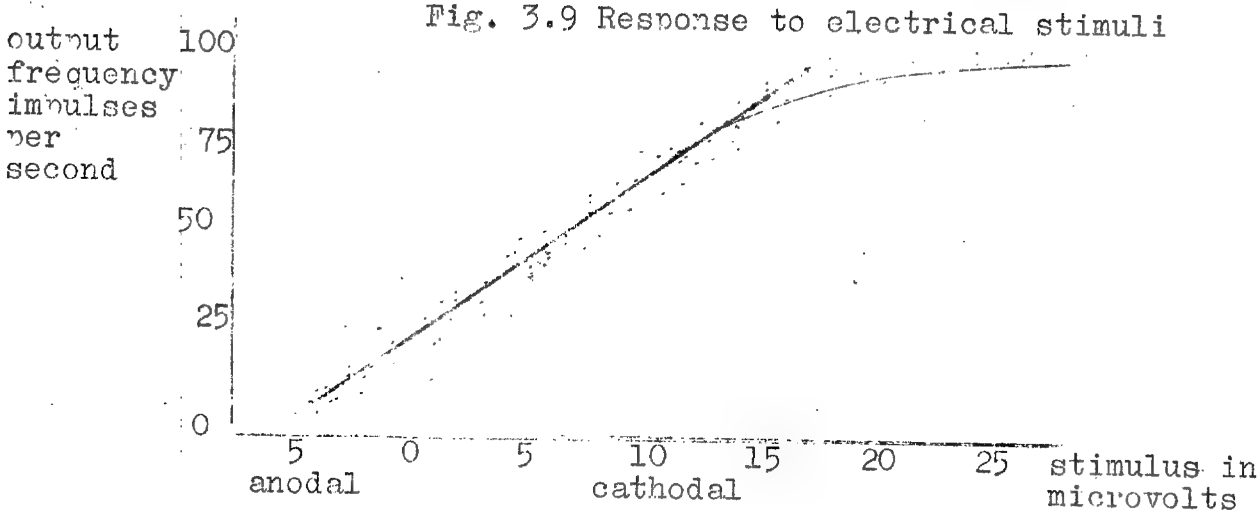


Fig. 3.10 Temperature

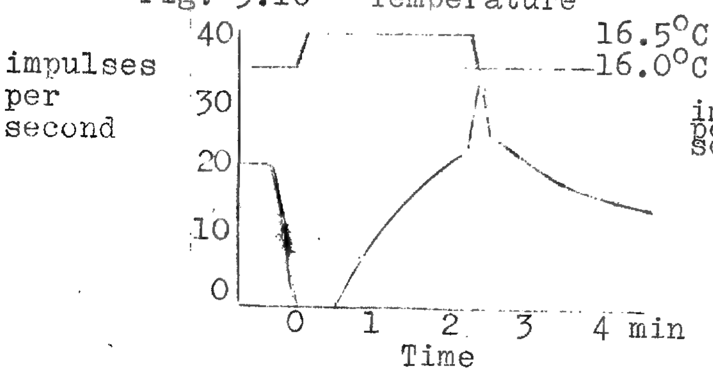


Fig 3.11 Pressure differential

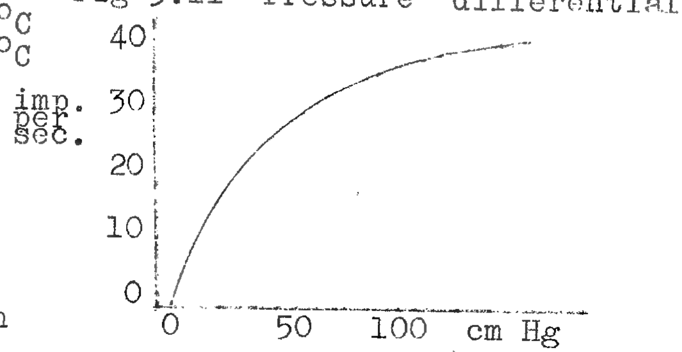
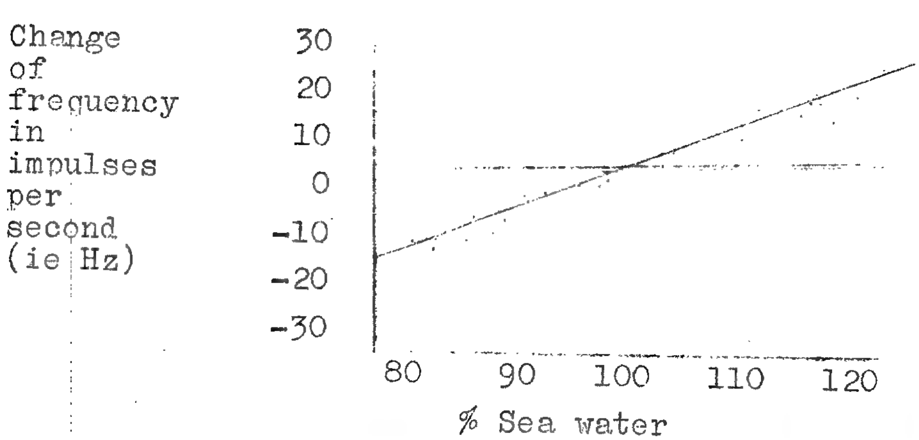


Fig. 312 Salinity



Returning to specific electroreception, it was observed that stimuli of duration 0.1 to 1.0 seconds were most effective in eliciting electroresponse. Waveforms of the above durations are equivalent to 10 Hz to 1.0 Hz frequencies. Also observed was the phenomena that stimuli that were either too brief, or sustained for too long were less effective in producing electroresponse. Along the same line, it was shown that stimuli that were either amplitude modulated or frequency modulated gave response when the field strengths were as low as 10 $\mu V \cdot m^{-1}$. The most effective frequency of frequency modulation was 3 Hz. Let the reader remember this, for in the next section, (on audition), it will be shown the the auditory sense, again, histologica derived from the LLO also demonstrates a propensity to selectivly respond to certain stimuli, if and only if that stimuli is either amplitude or frequency modulated.

In addition to the above electroreceptive characteristics, a phenomena of value to the biofeedback researches occurs when two electrosensitive species with electric organ discharges (EOD) were connected with contact electrodes. It was observed that when the two fish of the same specie, each with the same basic EOD frequency, were connected, both fish were observed to change their EOD in such a manne to produce dissimilar, that is divergent EOD. Scheich and Bullock indicate that this "jamming avoidance response" occurs so that each fish can discriminate its own neural patterns, such that confusion, and therefore less self control may be avoided. This JAR accurs only if the EOD's are within 15-20 Hz of each fish' own EOD, and is most pronounced when the difference is 3-5 Hz. This is related to the FM response to 3 Hz, since two fish within 3-5 Hz of each other will produce high amplitude 3-5 Hz modulation of each others EOD.

The phenomena of electroreception has been studied by the various psychologists, physiologists and biologiests, who deem the phenomena as necessary for the survival of the aquaric species observed. They call the phenomena electrolocation and electrocommunication, yet a perusal of their bibligraphies indicate that none has cited or studied the biophysical or parapsychological literatures, and their conclusion were thus reached independently.

In electrolocation, for example, in Eigenmannia, the males' basic frequency was 250-600 Hz, whereas the females' was 340-560 Hz. Similar an adversary or prey may be located at a distance thru electroreceptio

Again, certain current veloocities in the oceans or streams contain specific life forms, and it has been demonstrated that sensitivit to current velocities as low as 2.5×10^{-5} $m \cdot sec^{-1}$ exist. Another report indicates that 10^{-3} $m \cdot sec^{-1}$ may be used as a conditioning stimulus. In a similar study, a 2 µm vibration at 15 Hz resulted in a 50 Hz sign (Schwartz).

The ampullary organs, specifically electroreceptive, have been shown to have evolved indpendently in several species of vertabrates. And, altho the LLO are found only in water dwellers, evolution has produced two organs specifically derived from the LLO. At one time, olfaction, vision, and certain cranial nerves were part of the Lateral systems. In man, the vestibular canals (not uncoincidentally named Ampullae by anatomists), and the cochlea are directly descended by amphibial LLO. In the next section we shall show the very close similarity between the electroreceptive ampullary organs in water dwellers, and the acoustico-electro receptive vestibular and cochlear organs in man.

3.4 AUDITION and MECHANO-RECEPTION

Recalling that J. Rhine has indicated that GESP is ultimately processed thru the central nervous system and that the acoustico-lateralis system processes some electro-reception, it behooves us to study audition and the mechano-receptive functions, for it will be shown that there are generalized responses applicable to all sensory modaliti

The sensitivity to sound is in fact the sensitivity to mechanical vibrations set up in the atmosphere. The inner ear is the site of this acoustico-mechanical reception, and those familiar with audition know that the mechanical vibrations set up are relayed to the inner ear by a skin-like membrane, the tympanus, and then thru three small bones, the malleus, the incus, and the stapes to the inner ear which contains both the semicircular canals and the cochlea, both of which innervate the eighth cranial nerve. It has been shown by von Bekesy, who won the Nobel Prize for his work, that the process of audition includes that of bone conduction as well as the response of the whole body to mechano vibrations. And altho audition is a specialzed sense sequestered from spurious vibrations, we shall show later how the whole organ of the ski is a kind of mechano-receptor, the results applicable to "dermo-optics. In addition, the skin is the site of contact electro-reception, and it shall be shown the similarities between these various sense modalitie

Specifically, the organ of audition is the organ of Corti located in the center of the cochlear spirals. The Organ of Corti is a layer of hair cells connected tothe basilar membrane which connects directly to the eighth nerve. There are about 15,000 hair cells on the basilar membrane and a total of about 15,000 neuron fibres in the coclear nerve These hair cells range in size from about 130 μm, which are high freque cy responsive, to 275 μm, which are low frequency responsive. Of unusual interest is that these nerve fibres have afferent nerve ending, tho there is no motor function to be found, and in addition the potenti across the hair cells in the organ of Corti is about 140 mV. Since these cells are approximately 140 μm in length, the field strength represented in the organ of Corti is:

$$3.9 \qquad E = dV \cdot ds^{-1} = \frac{1.4 \cdot 10^{-1} V}{1.4 \cdot 10^{-4} m} = 1.0 \cdot 10^{3} \ V \cdot m^{-1}$$

The hair cells in the organ of Corti relay the mechanical vibratic set up upon them from the stress-strain reactions caused by their bendi a heat set off by the friction then stimulates, thru this piezoelectric process, the generator potentials. Of interest is that, up to 60 Hz, the output frequency response is an exact match of the input frequency response. Above this frequency specialized areas in the cochlea at specific distances from the stapes produce complex volleys responsible for audition at these frequencies. In addition, the three semicircular canals, which resemble three mutally pendicular half-loop antennae, are also innervated by cupulae and microvilli which also respond in piezoelectric process to mechanical bending set up by change in velocity and acceleration. These semicircular canals are about 1 cm in heighth, and thus may provide electroreception form EMR in this wavelength.

Our interest in audition stems from that sense modalities' relatio ship to the lateralis system, but also from the fact that audition is a sense modality concerned with the frequency and the intensity of the impinging stimuli. Altho the energy intensity by which audition is measured is usually Watts per centimeter squared ($W \cdot cm^{-2}$), the various energy dimensions are interchangeable, like meters into feet, and it can be directly shown that the electro-sensitivty threshold may be computed directly from the audition thresholds. (Cf 3.5)

Since, as we have indicated, that audition is a skin membrane, bone conduction phenomena, and that there exist several formulae relating skin area to height and mass, and the proportion of bone mass to total organism mass, it is not surprising that a mathematical relat ion ship exists between auditory thresholds and physical body measurem ments. Masterson and Diamond have empirically produced the following relationships, Eq. 3. shows that the lowest frequency responded to is related to body mass, and that in addition, the high frequency threshold is a mathematical function of the low frequency cutoff threshold.

3.10 $\log f_{low} + \log_{mass\,(kg)} = 2.5$

3.11 $f_{high} = 20\ \text{kHz} \times \log f_{low}$

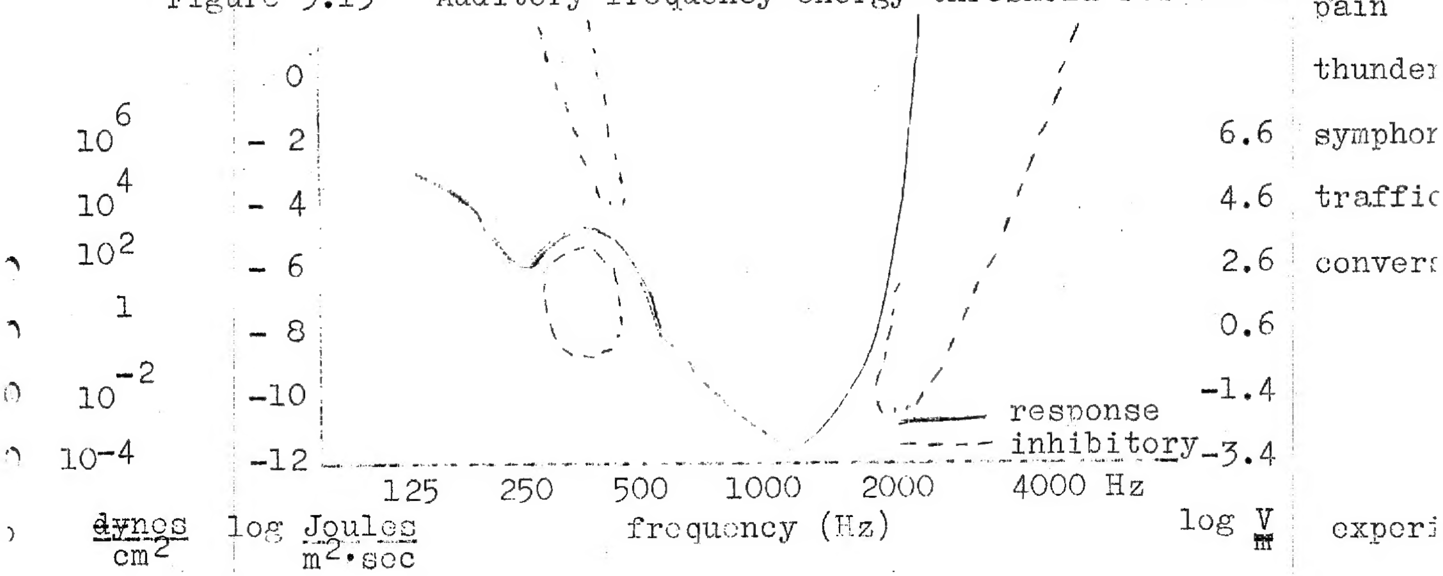
Other physiological aspects of audition illuminate processes relevant to extra, or as one professional calls it, expanded sensory perception. Von Bekesy studied the auditory thresholds with respect to three variables; heredity, age, and real time. He found for instan that the audiograms of members within a family were significantly similar, whereas an audiogram of someone not in that family differed as well significantly. Viz, a proof of the heredity of sensory and perceptual abilities and responses. In addition it was found that with increasing age, the ability to perceive sound frequencies and intensities was attenuated at the high frequency response band, but was basically unchanged at the low frequency end of the acoustical spectrum. Of very specific interest to perception was von Bekesey's observation of the following. Audiograms were made of subjects' threshold sensitivities at two frequencies, 200 Hz and 1000 Hz, and observed for a duration of twenty minutes. It was found that the thre holds varied 5 to 15 db with periodicities of 8 minutes for the former and 6½ minutes for the latter. It would prove to be highly illuminating to discern if each frequency had its own periodicity of threshold sensitivy, for in addition, periods of 8 minutes and 6½ minutes are in effect frequencies of 1/480 seconds and 1/390 seconds, and it is well demonstrated that higher frequencies are harmonics of lower frequencies, and we may summize ultra-low frequency modulation or driving of higher frequency acoustico-mechano-electro-sensitivities.

In this section we shall observe the various response characteristics of the auditory system in order to establish the limits of the energy perceived. It has been adopted as convention that the root-mean-square threshold for audition is 0.0002 $dynes \cdot cm^{-2}$ at 2000 Hz, the fequency of highest sensitivity. However, von Bekesy has observed sensitivity thresholds of 0.00005 dynes.cm-2 at 2200 Hz. Therefore, while we shall discuss standard auditory thresholds, but again the reader is cautioned that the demonstrated human perception thresholds may vary as much as 5 to 15 db below the 50% population standard threshold.

Like the electroreceptive senses (ELF, infra-red, and vision), audition is ergotonic, that is, its sensitivity of energy (ergo) is a function of the frequency (tono) of the impinging stimuli. Also, like the electroreceptive senses, audition shows the property of excitory and inhibitory response. That is, most neurons have a base, that is a static discharge rate, so that, while some stimuli cause an increase in the neural discharge rates, some stimuli cause an inhibitic that is decrease of the static discharge rate. This is a very interesting aspect of sensation and perception, for the percipient must be aware that the information is "the absence of information,", or to put it crudely, the percipient is required to be aware not of the donut, but the hole.

Figure 3.13 below is the oft reproduced and now standard auditory intensity-frequency response chart. The sound pressure level is given in dynes$\cdot$cm^{-2} and Joules per square meter per second on the left hand ordinate and (tentatively) Volts per meter per square root of the frequ-ncy ($V \cdot m^{-1} Hz^{-\frac{1}{2}}$) on the right. It is convenient to use $J \cdot m^{-2}$ sec^{-1} rather than Watts$\cdot$cm^{-2} because we should like to be able to calculate the energy in a given frequency waveform. (See the next section for conversion factors.)

Figure 3.13 Auditory frequency-energy threshold responses



Additional evidence for the coding of sensory information into the ELF band can be seen in Figure 3.14 below, which charts the frequency of the neural impulses in response to a given stimulus intensity input for neurons with frequency-specific responses. Notice that the hyperbolic tangent (tanh x) growth rate saturates at about 450 Hz.